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5. Let geodetic lines issuing from the same point upon a line of curvature, and passing through the umbilics  $o, o'$ , meet the line of curvature again in the points  $p, p'$ . Then will the locus of the point of concurrence of the geodetic lines  $op', o'p$ , be a line of curvature of the same species as the given one.

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The following note, by Mr. M. Roberts, on a theorem relating to the Hyperbola, was also read :

Let  $s$  denote the difference between the infinite arc and the asymptote of the hyperbola, whose equation is

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 ;$$

and let  $s'$  be the length of the quadrant of the curve which is the locus of the feet of perpendiculars dropped from the centre upon its tangents ; also, let  $\Sigma, \Sigma'$  denote the same things in reference to the conjugate hyperbola

$$\frac{x^2}{b^2} - \frac{y^2}{a^2} = 1,$$

and we shall have

$$ss' + \Sigma\Sigma' = \frac{1}{2}\pi \left\{ \frac{a^3}{b} - \sqrt{a^2 - b^2} s \right\}$$

where we suppose  $a > b$ , and denote by  $s$  an arc of the first hyperbola, measured from the vertex to the point whose coordinates  $(x', y')$  are

$$x' = \frac{a^2}{b}, \quad y' = \sqrt{a^2 - b^2}.$$

If  $a = b$  the hyperbola is equilateral ; the derived curve is the common lemniscate,  $s = \Sigma, s' = \Sigma'$ ; and

$$ss' = \frac{1}{4}\pi a^2,$$

a theorem proposed by Mr. W. H. Talbot, and proved by M. Sturm, in vol. xiv. of Gergonne's *Annales de Mathematiques*, page 17.

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Professor Harrison read the following paper on the anatomy of the elephant :

“ Having had, within the last few weeks, an opportunity of examining the body of an elephant which died in this city,

I have dissected different portions of it with some care, and shall lay before the Academy, at the present Meeting, a section of the recent skull, also the brain, and a minute dissection of the nerves of the proboscis on one side. As my time has been limited, and much engaged with other matters, I shall not enter into a minute examination of these parts, but merely exhibit such striking characters and peculiarities as are likely to engage the attention of those who are not fully acquainted with the subject. I may observe that, in the course of my dissections, I have ascertained some points which I do not find noticed by preceding writers, and others which have been stated differently from what I have found. Thus, among the ocular appendages, the membrana nictitans, or third eye-lid, presents some interesting relations; in the orbit I do not find any retrahens oculi muscle, as is to be inferred from the descriptions in books; I also observe a second external rectus muscle. In the ear also I find a peculiar arrangement of the muscles of the ossicula auditus; and I see no evidence of the muscular structure of the membrana tympani, so accurately described by Sir E. Home in the *Philosophical Transactions*, and mentioned by subsequent writers, who seem to have adopted his opinions, rather than to have examined the organ for themselves. In the thorax I have remarked the absence of the pleural or serous membranes; and I find the lungs are connected to the parietes by a great quantity of filamentous and yellow tissue, yielding and elastic. I have also discovered a remarkable muscle extending from the back part of the trachea to the œsophagus, near its passage through the diaphragm, of which I can find no previous notice. The rudimentary condition of the gall bladder in the abdomen, as well as the mucous membrane of the small intestines, and the reproductive male organs, present certain peculiarities, which do not appear to me to have received sufficient attention. I shall not allude further to any of these points at present, but as time permits me to complete their examination, and to prepare suitable illustrations, I hope to place some additional remarks

before the Academy, which may tend to enlarge our knowledge of the anatomy of this very interesting animal.

“ One of the earliest dissections of the elephant on record is that which was made in Dublin, in 1682, by A. Moulin, a medical graduate of Trinity College. This animal was destroyed by a fire which accidentally occurred in the city. In the volumes of the *Philosophical Transactions* several papers have been published on the anatomy of particular parts of this animal. Camper’s description and plates have added much to our knowledge; but the most complete and concise description is to be found in the *Encyclop. Method.* vol. iii. p. 173. In Cuvier’s system of comparative anatomy several of its peculiarities are noticed; and in his splendid work, *Ossemens Fossiles*, tom. i. p. 12, its osteology has been minutely and carefully described.

“ The subject of this examination was an Indian or Asiatic elephant, one of the family of the *Pachydermata*, which may be regarded as a distinct genus, under the name of *proboscidean*, as no other animal possesses the true and perfect proboscis or trunk. Of this genus there are only two living species, the Asiatic and the African, which are distinguished by certain well-marked differences: the head of the Asiatic is large and oblong, the forehead concave, the external ears small, and the molar teeth present undulating transverse ridges of enamel, which are the separations of the laminæ which compose them, worn down by trituration; the head of the African is round and smaller, the forehead convex, and the ears very large, and the molar teeth are marked with lozenge-shaped ridges of enamel.

“ The present animal was not full grown; he was supposed to be nine or ten years of age, was about six feet high, and six and a half from the top of the head to the root of the tail; he had latterly increased considerably in height and size, had always enjoyed perfect health until within a few days of his death, which was the result of an acute fever. No organic disease could be detected in any part of his system.

“ The large expanse of forehead, the peculiar expression of

countenance of the elephant, together with his well-known docility, lead to the presumption that this animal must possess a brain of considerable magnitude. Although this is really the case in a remarkable degree, yet the external skull is by no means a measure of the organ within. I now place before you a horizontal section of the cranium of this animal ; and it exhibits two remarkable facts, first, the small space occupied by the brain, and secondly, the beautiful and curious structure of the bones of the head. To the latter we may first direct our attention. The two tables of all these bones, except the occipital, are separated by rows of large cells, some from four to five inches in size, others very small, irregular, and honey-comb-like; these all communicate with each other, and through the frontal sinuses with the cavity of the nose, also with the tympanum or drum of each ear; consequently, as in some birds, they are filled with air, and thus, while the skull attains a great size, in order to afford an extensive surface for the attachment of muscles, and a mechanical support for the tusks or the enormous incisor teeth, it is at the same time very light and buoyant in proportion to its bulk ; a property the more valuable, as the animal is fond of the water, and frequently takes to it, and swims and bathes in deep rivers. All these cells are lined by a delicate mucous membrane of a light rose colour, being slightly vascular, like that in the frontal sinuses, of which cavities these cells may be considered as an extension, rather than as analogous to the diploe in other animals. The septa between the cells are vertical, and pass from the outer table to the inner ; they are very hard and vitreous, whereas the outer table is of a coarse and porous texture. These septa strengthen the whole fabric, the outer table abutting against them ; some rows are separated from others by horizontal shelves. This structure also extends into some of the bones of the face, and into those at the base of the cranium, the pterygoid processes, and the condyles of the occipital ; but all the superior part of the last-named bone is devoid of them, the two tables being close and thin, and the bone

diaphanous. A deep depression exists in this region, at the bottom of which is a slightly prominent crest, and on either side a very rugged surface for the attachment of the ligamentum nuchæ, which substance I now also place before you ; it is a yellow, elastic tissue of immense strength, attached by thick roots to the spinous processes of the vertebræ ; ascending thence it divides into two thick vertical and diverging plates, which are inserted into the rough surfaces of the occipital bone already alluded to, and it is worthy of remark, that each fasciculus or lamina of these plates of yellow tissue first ends obliquely in a round tendinous cord, and it is through the medium of an infinite number of these tendons the attachment to the skull takes place. This peculiar structure is well seen in the preparation on the table ; its design, most probably, is to effect a more intimate union with the bone than the elastic tissue could obtain. The internal table of the cranium is thin, but very hard and vitreous, and the base is rough and irregular ; the cribriform plate is very broad and deeply depressed, with numerous foramina for the passage of the olfactory nerves, which are also numerous and large ; the foramen for the nasal branch of the ophthalmic is also very large ; the optic holes are small ; there is little or no sella Turcica, and there is no distinct pituitary body attached to the brain ; some vascular and fibro-cellular tissue corresponds to its situation : the foramen rotundum is very large, to transmit the superior maxillary nerve, which is of prodigious size.

“I next place before you the cast of the encephalon, and two drawings, one of its upper, the other of its under surface, both of the full size ; also portions of the organ hardened in spirits. The brain, though very large, forms a diminutive contrast to the immense cranium. On examining the three divisions of the encephalon, I found the anterior lobes of the cerebrum to be but of moderate size, narrow anteriorly, and arched a little downwards ; beneath each is the olfactory lobe, of considerable size ; its rounded oval ganglion was so depressed into the ethmoidal recesses, that it was necessary to cut through each

of them in removing the brain; each of these lobules or ganglions contained a large ventricle with smooth surface, and communicating with the lateral ventricle. The middle lobes of the cerebrum are very large and of great transverse breadth, like those of the cetacea, as may be seen by comparing them with the brain of the porpoise upon the table: there are no posterior lobes. The cerebellum is of considerable extent, both transversely and vertically, and abuts against the posterior inferior margin of the cerebrum; the mesocephale or cerebral protuberance is very large and broad, and the crura cerebri on leaving it are of great thickness; the medulla oblongata is highly developed, and not only the anterior pyramids, but also the olives, are of great size; the tubercula quadrigemina and pineal body are small, not much larger than the human; the optic nerves also are small, and the fourth pair are about the same size as in man; the fifth nerves are of prodigious size; the seventh also are rather large. The weight of the encephalon was eleven pounds ten ounces, but, allowing for the loss of some portions of the surface injured in the removal, also for the olfactory lobes, and the empty state of the vessels, it may be fairly stated as twelve pounds, Troy weight. On weighing each part separately, the cerebrum was seven pounds and a half, the cerebellum was four pounds, and the mesocephale and medulla oblongata half a pound.

“ Thus the brain of this young elephant weighs twelve pounds, while that of the full-grown horse does not exceed two pounds, and that of man seldom equals four pounds. From an examination of the brains of 150 men, the average weight of this organ was found to be about three pounds eight ounces, but exceptions occasionally occur, thus the brains of Cuvier and Dupuytren are recorded as nearly five pounds Troy weight. From an examination of ninety females, the average weight of the brain was three pounds four ounces, that is, about four ounces lighter than that of man. The brain of the idiot is seldom more than one pound and a half. These are the general results of the observations of Tiede-

mann,\* and of the extended series of inquiries of Sir W. Hamilton† of Edinburgh, Mr. Sims,‡ and Dr. Reid.§ In considering the brain, however, in relation to the nervous function, many other circumstances are to be attended to beside the actual size or weight of the organ, namely, its weight compared with that of the body, the relative proportion of one part of the organ to another, as the cerebellum to the cerebrum, the relative size of the brain to that of the nerves connected to its base, and, above all, the structure of the organ, the size, number, and depth of the convolutions, and the extent and thickness of the encrusting lamina of the vascular, or grey vesicular neurine, which there are good reasons for believing to be the essential dynamic agent in the function of innervation. The weight of the human brain, compared to the weight of the whole body, is as one to forty-five or fifty, supposing the former to be about four pounds, and the latter to vary from 180 to 200 pounds; whereas, the proportion in the elephant will be as one to 400 or 500, supposing the former to be twelve pounds, and the weight of the body to be only from two to three tons. The weight of the present specimen, which was by no means full grown, was about two tons. Therefore, the human body is only forty-five to fifty times heavier than the brain, whereas the elephant's body is four or five hundred times as heavy as its brain: then again the human cerebellum is much smaller than the cerebrum, being in the proportion of one to eight or nine, but in the elephant, the proportion is as one to two: therefore, the human cerebrum is eight or nine times larger than the cerebellum, whereas the cerebrum of the elephant is only twice as large as his cerebellum. These relative proportions are interesting and important, if, as we believe to be the case, the cerebellum be connected with the functions of the general muscular system, and the cerebrum with the manifestations of the mental principle. It must be admitted, however,

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\* Phil. Trans. 1836.

† Munroe's Anat. of Brain, 1831, p. 4.

‡ Med. Chir. Trans. vol. xix. p. 359.

§ Lond. and Edinb. Monthly Journal of Med. Sci., April, 1843.

that conclusions drawn from the relative weight of the brain and of the body are open to many objections ; as the weight of the latter must be influenced by the previous state of health, of fulness or of emaciation ; the weight of the brain too must be materially affected by the amount of fluid it contains, or which may have escaped during the operations of removal and of weighing. Attention to the relative structure of the brain, therefore, is also necessary. The convolutions of the elephant's cerebrum are very numerous, but rather small, and but few of the sulci are deep ; the fissure of Sylvius is closed, and therefore that numerous group of convolutions forming the "island of Reil" are absent ; the grey neurine is not so thick as in man : on the whole, the cerebrum bears more analogy to that of the porpoise than to that of man, in whom the convolutions are large and numerous, the sulci deep, and many of them involuted over and over again. In man, too, the fissure of Sylvius is very deep, and when opened out presents a prodigious number of convolutions ; his posterior cerebral lobes are extensive, and overlap the cerebellum ; the grey neurine forms a thick investing lamina, the superficial extent of which is increased to a wonderful extent, and to a degree superior to what it is in any other animal.

"I shall next place before this meeting a dissection of the *proboscis* or trunk of the elephant, the organ which forms the striking and characteristic feature of this group of animals, no other possessing it in a perfect state, though in many it is rudimentary, as in the tapir and in the pig. It is essential to the existence of this animal, as the instrument for taking its food, and hence its name ( $\pi\rho\omicron, \beta\omicron\sigma\kappa\omega$ ). Its length varies from four to six feet, according to the height of the animal ; it is of a conical form, the base is attached to the nose, of which it may be regarded as a continuation, and is about two feet in circumference ; the apex is from four to six inches ; the fore-part and sides are convex, and marked by rugged, transverse folds, which admit of extension and change of form ; the posterior surface is flat and rough, and bounded

on each side by a row of rough tubercles : the whole is covered by a coarse, hard skin ; this being removed, the proper structure comes into view. The proboscis consists of two long tubes separated by a median septum ; these tubes open above into the nose, and below at the extremity of the trunk ; they are somewhat contracted at each of their extremities ; they are composed of a whitish membrane, not very vascular or sensitive, covered by a dense elastic tissue, which preserves their calibre ; inferiorly the skin is continuous with the lining membrane. The point of the proboscis is worthy of attention, a thick lip surrounds it, with a groove below, and a thumb-like projection above ; this little conical appendix enjoys free motion, and can be brought into contact with every part of the border. The skin being removed from the proboscis, the muscular tissue which composes the principal portion of the entire mass is exposed ; this is arranged, partly in superficial strata, and partly in deeper seated, radiating, and decussating fasciculi. The first layer consists of strong, red, longitudinal fasciculi, which extend, from the frontal and nasal bones, the entire length of the organ ; some of the fasciculi are short, and end between two others ; some are intersected by tendinous lines, which adhere to the integuments : on each side of the trunk also are seen longitudinal muscles extending downwards from the superior maxillary bones and commissures of the lips. As these fasciculi descend they spread out obliquely, some forwards, others backwards, or to the under surface ; some intermingle with the other superficial muscles, others are inserted into the tendinous interlacements of the deeper muscles, and some into the skin ; the posterior or flat surface also is covered by muscular fibres, which take a decided oblique course, attached above to the intermaxillary bones in front of the mouth ; they descend in different laminæ, some obliquely inwards, and join those of opposite sides, in a median tendinous raphé, which extends the whole length of this flat surface of the trunk ; this muscular lamina is not so red or longitudinal as those on the front and sides ; this lamina may also be

partially divided into two layers, the fibres of the deeper layer passing obliquely downwards and outwards, and decussating the former. All these investing muscles which you now see exposed on one side, must have the effect of moving, bending, and curling this organ in every direction ; the animal can thus bend it upwards over his head, or downwards between his legs, or on either side along his neck.

“ On one side we have raised these longitudinal muscles, and in doing so we perceive some of the principal nerves descending in tendinous sheaths or canals. To these nerves we shall more particularly allude directly. These sheaths are connected to the muscular fibres on either side, and resemble the tendons of digastric muscles ; there are several laminae of these, through and between which the principal nerves descend, and are thereby protected from the pressure of the contracting muscles, as, during the action of the latter, these canals will be enlarged rather than diminished. Beneath all these long muscles, but intimately united to them, we meet another portion of muscular structure, which extends from the longitudinal fibres, and from these tendinous canals obliquely inwards, to be inserted into the parietes of the tubes. If we look at the upper extremity of the proboscis, which has been cut off from the skull, the course of these fleshy fibres is evident ; they present a radiated appearance, as they pass from the central tubes outwards to be inserted, some into the longitudinal fibres, others into the tendinous canals for the nerves just mentioned, and others pass between the longitudinal fasciculi to the subcutaneous aponeurosis. Some have attempted to count the number of these muscles, but such an attempt is totally useless. These radiated fibres, by their contraction, can approximate the parietes of the tubes to the skin, and at the same time compress the general structure of the trunk, and thus tend to its general elongation, when the longitudinal fibres are relaxed ; while by this arrangement, also, circular compression or constriction of the tubes is avoided, which must have been the effect if the fibres pursued a circular course. At the

upper or cranial extremity, however, some strong fasciculi take a semicircular course around its anterior and lateral surfaces, and are attached to the bones on either side ; and around the lower end also are some oblique and partly annular fibres, which are attached to the central appendix and to the border on either side.

“ I shall next allude to the nerves which are distributed to the proboscis, and which extend its entire length : they are four in number, that is, two on each side, and, like the muscles, are symmetrically arranged ; these nerves are the facial, or the portio dura of the seventh and the infra-orbital or supra-maxillary division of the fifth cerebral nerves. These nerves are remarkable for their size and length, and for the numerous plexuses they form with one another. The portio dura, or the seventh, is about the size of the little finger, and between the point of its exit from the stylo-mastoid foramen in the base of the skull, and its entrance into the proboscis, pursues a curved course about two feet in length ; in this course it sends many branches to the glands and muscles on the side of the face, and then enters the upper and lateral part of the proboscis between the anterior and lateral longitudinal muscular fasciculi, and is joined in this situation by the superior maxillary nerve, the second division of the fifth pair ; this great nerve, fully the size of the middle finger, escapes from the infra-orbital foramen, gives off a few branches to the lower eye-lid and to the integuments, and then descends into the same sulcus in the proboscis with the seventh. The two nerves now unite, but they soon separate and divide, the divisions reuniting so as to form a most intricate nervous plexus ; and, as you may observe in the dissection before you, these nerves pursue a similar arrangement during their long course down the trunk, until within a few inches of the extremity. This chain of plexuses resembles a thickly tangled skein of silk extending from one end to the other. When the dissection is carried deeper, the same plexiform appearance is observed, the nerves running in the tendinous sheaths, already described, in courses one beneath the

other. From the larger nerves innumerable fibrillæ cross in every direction to supply the surrounding muscular fasciculi. Language can convey no adequate idea of the number and plexiform arrangement of these proboscidean nerves; and, although in this dissection many hundred are brought into view, I have no doubt as many more could be displayed, if sufficient time could be afforded to the tedious process of exposing them. The plexiform arrangement of the seventh and fifth nerves on the human face, though anatomically and physiologically analogous to these, yet bears no comparison as to size, number, or complexity. From the intimate union between the seventh, which is the nerve of motion, and the fifth, the nerve of sensation, the greater number of the branches derived from these plexuses must be compound filaments, and, therefore, supply the parts to which they are distributed with the two endowments, motion and sensation. In this dissection, however, I have in several situations unravelled the nerves in the plexus to their respective sources, and traced fine filaments from the fifth or sentient nerve, inwards to the lining membrane; and have also pursued some very large branches of the same nerve, undivided, down to within two or three inches of the proboscis, where they separate into fine hair-like branches, about twenty of which are exposed in one situation, all descending in parallel lines to the very border of the opening, where they branch off into minute filaments, and terminate in the subcutaneous tissue.

“ I shall not delay you with any minute account of the blood-vessels of this organ, and shall only observe, that they are very large and very numerous. Some of the principal trunks accompany the nerves, but many others run in channels through the muscular substance, and distribute their branches to it in every direction.

“ I shall next place before you a dissection of the cartilages of the true nose, which are connected above to the nasal bones, and below to the proboscis. These cartilages present a long, curved tube, which is convex forwards, and divided into two

tubes by a median cartilaginous septum. The tubes of the proboscis communicate with these, and so with the nares and throat. The lateral cartilages are very elastic, and lie so close to the septum as partially, but not completely, to close this communication ; but between the lower border of each cartilage and the proboscis are some strong muscular fibres, which can compress the connecting membrane, and thereby perfectly close the upper end of each proboscidean tube, and so prevent the fluid which the animal draws into these from rising into the nose and flowing through the nares into the throat.

“ The lining membrane of these cartilaginous nasal tubes is somewhat of the same nature as that which lines the nares, which is thick, soft, and vascular, and very superior in organization to that which lines the proboscidean canals. In the latter there are no olfactory nerves, and no sense of smell ; this sense resides, as in other animals, in the true nose.

“ From the anatomical examination of the complex structure of this very curious appendix, we can understand the powers it displays, and the purposes it effects in the economy of the animal to which it appertains. Its muscularity and its pliancy render it, as a weapon of offence and defence, powerful and effective. With it he can strike down an animal, or can raise it into the air and dash it to the earth ; or he can bend it round its body or its neck, and crush it by powerful compression. It can tear down large branches of trees, and raise and propel great weights ; hence the great value of the elephant in warfare, and in marshy countries, as a beast of burden, for the transport of heavy guns and cumbrous baggage. In such services his exertions are well-known, and have often excited admiration and surprise ; the more so, as the docility and intelligence of the animal enable him to direct his physical strength with the degree of energy and skill exactly suited to accomplish the desired object.

“ For the prehension of food the proboscis is indispensable to his existence ; by its means he plucks off branches and leaves, blossoms and fruits, and tears away the herbage, gathers

all into a mass, and, as with a hand, places it within his mouth. With it he sucks up a large draught of fluid, closes the communication with the nose, and then turns its spout-like extremity into the mouth, the anterior part of the latter being so shaped as accurately to receive the contents.

“As the prehensile organs for food in other animals possess the sense of touch, whether they be lips or anterior extremities, so the tapering end of this organ enjoys exquisite sensibility and delicate motor power. By its thumb-like appendix he can pick up the smallest substance from the ground, hold it, and turn it in every direction, to examine it with accuracy before he commits it to his mouth. He can also execute (especially in his captive state, when taught and encouraged by kindness) a variety of delicate manipulations with astonishing dexterity.

“This organ also enables him to remain in deep water, his whole body immersed and concealed from view, except the point of the proboscis, which appears just over the surface, and through which respiration is conducted, occasionally drawing in a little fluid, and then ejecting it with force, not unlike the “jet d’eau” from the blow-hole on the head of the cetacea. By it also, when on land, he can dash water, sand, and mud all over his body, so as to cool and refresh the surface, and remove any source of irritation. Finally, by this instrument he can modify his voice, and increase its tone, so as to cause it to be heard at a distance of one or two miles, and, according to some, still more. Through it he can send forth trumpet sounds, loud, harsh, and discordant, but varying according as they are indicative of social or sexual feeling, or of terror, anger, or satisfaction.”\*

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\* Since the above went to press I have found, in the library of Trinity College, A. Moulin’s pamphlet on the dissection of an elephant, published in the form of a letter to Sir William Petty, Lond. 1682. He has correctly noticed the absence of pleuræ or pulmonary serous membranes. The brain, in his specimen, which was older and larger than mine, weighed ten pounds (I presume avoirdupois), or between thirteen and fourteen pounds Troy weight.